INVESTMENT ANALYSIS REPORT FOR FLIGHT SERVICE STATION VOICE SWITCHING CAPABILITY

Mission Need Statement 320

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For a summary of the recommendations of the investment analysis for flight service station voice switching capability, refer to Section 6

INVESTMENT ANALYSIS REPORT FOR FLIGHT SERVICE STATION VOICE SWITCHING CAPABILITY

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1.   INTRODUCTION

1.1   Background

Flight service stations (FSSs) provide several essential services to users of the national airspace system (NAS). These services include preflight weather briefings, airport advisories, acceptance of flight plans, en route (real-time) weather advisories, broadcast weather information, Notice to Airmen classification and dissemination, monitoring of emergency communications radio frequencies, search and rescue initiation and coordination, and air/ground communications services for commercial, general aviation, and military pilots.

There are 61 automated FSSs (AFSSs) located throughout the United States and in Puerto Rico. In Alaska, there are 14 non-automated FSSs situated in remote areas that generally are accessible only by air. Although much smaller and less sophisticated than the AFSSs, the FSSs play a critical role in delivering air traffic services, as well as advisory information, to aircraft in these remote areas.

Communications between pilots and air traffic control specialists are enabled by a solid-state voice switch at each of the AFSSs. At the Alaska FSSs, communications are enabled by a combination of solid-state and electromechanical voice switches. All these voice switches interface with two basic types of specialist positions; an in-flight (air/ground) specialist position and a preflight (ground/ground) specialist position. Each type of position supports a distinct set of specialist functions. In-flight specialists communicate with pilots of aircraft in flight, while preflight specialists provide services to pilots in advance of actual flight. All specialist positions support intercom (intrafacility) calls, interphone calls (over dedicated/direct-access lines to other air traffic facilities), and dialed (indirect-access) calls to external parties using public switched or other telephone networks.

The voice switches connect in-flight specialists with radios at remote communications outlets (RCOs) to enable two-way communications with aircraft in flight. An in-flight specialist responds to a contact (a radio call from a pilot) by identifying the RCO accepting the call and activating that RCO's radio transmitter through the voice switch. Across the nation, in-flight specialists presently handle more than three million contacts in a year, and that number is expected to increase in the future.

At an AFSS, a preflight specialist and a pilot desiring preflight services are connected by means of an Automatic Call Director (ACD). The ACD accepts the pilot's incoming call to a telephone number that is common throughout the continental U.S. and routes it to one of several AFSSs that will provide weather data and other information relevant to an anticipated flight. The pilot

has the choice of listening to recorded information that can be selected via his/her telephone keypad or of waiting for a preflight specialist to answer. Recorded weather, aeronautical, and other data and announcements are presented to pilots by a Voice Retrieval System (VRS). Preflight specialists who record this information access the VRS through the voice switch. Recorded information also is available to aircraft in flight via broadcast transmissions over selected navigation and landing aids. Figure 1-1 shows the locations of the AFSSs.
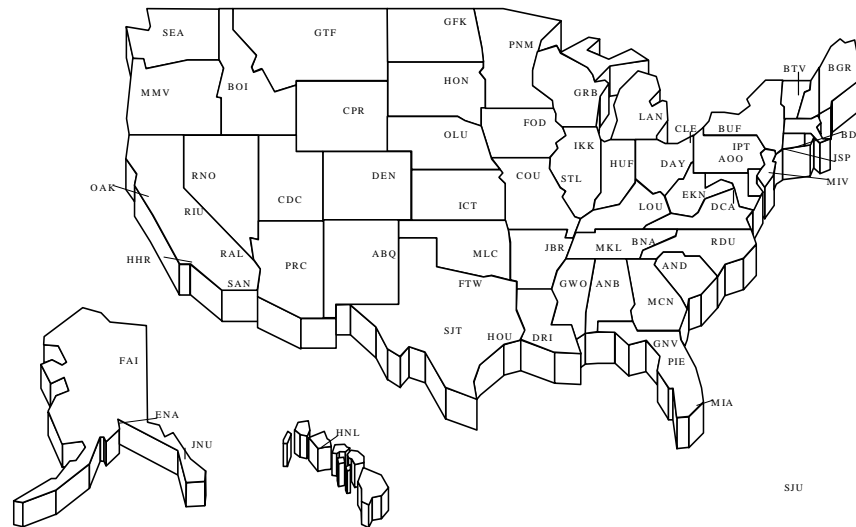

Figure 1-1. Locations of Automated Flight Service Stations

1.2   Need to Enhance Flight Service Station Voice Switching Capability

Voice switching capability at the 61 AFSSs currently is provided by the Type III Integrated Communications Switching System (ICSS), an analog voice switch fielded in the 1980s. The ICSS was planned to have a twenty-year service life, and switches were purchased from two vendors, Litton and Denro (Litton recently acquired Denro). Of the 14 non-automated FSSs in Alaska, eight have electromechanical voice switches of mid-1960s vintage, and the other six have Small Tower Voice Switches (STVSs) that were installed in the late 1990s.

Mission Need Statement (MNS) 320, *Voice Switching Capability for Flight Service Stations* [Ref. 1][1], sponsored by the Air Traffic Services line of business and approved by the Joint Resources Council (JRC) on 5 August 1997 [Ref. 2], describes the need to sustain and enhance FSS voice switching capability through the next decade. A cited basis for this need is that half of the fielded ICSSs (those purchased from Litton) economically will not be supportable beyond June 2002, and that the remainder (purchased from Denro) will reach the ends of their economic service lives shortly thereafter.

The principal enhancement sought is a capability to transfer air/ground and interphone calls normally handled at a given AFSS to other AFSSs (the capability henceforth is identified as "air/ground call transfer"). With such a capability, some AFSSs temporarily could cease operations during periods of low demand for flight services (e.g., at night). This operational

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[1] References are identified and described in Appendix A.

concept is described in a staff study of the Flight Service Architecture Core Group [Ref. 3]. Implementation of air/ground call transfer will require the following:

- A call transfer capability associated with the voice switch at each AFSS which is to operate on a part-time basis[2]
- Supporting ground telecommunications service to link the AFSSs operating part time with the AFSSs to which the former's air/ground (and associated interphone) calls will be transferred
- Ability to accept, display, and handle transferred calls at the voice switch and specialist positions of each AFSS identified to receive such calls.

The sponsor currently envisions that part-time operations will be implemented within "clusters" of two or three proximate AFSSs, wherein one would operate full-time and the other(s) would operate part-time.

During the latter part of 1999, the sponsor determined that there existed considerable specialist dissatisfaction with the current user interface for the ACD and VRS and asked that improvement of this interface be included as an enhancement to AFSS voice switching capability. It was agreed that this operational need would be addressed during the investment analysis.

There also is an implicit need for a switching system that readily can adapt to changes in the provision of FAA voice communications service anticipated to occur over the coming decade, notably widespread migration to common-user telecommunications networks employing digital technology and techniques. Such a switching system is designated as the Voice Switch Replacement System (VSRS) in the current NAS architecture [Ref. 4]. The VSRS is portrayed as being modular and scalable, providing a common technological platform to modernize voice switching for flight services and throughout the NAS in the coming decade.

On 15 May 2000, the sponsor revalidated the need to sustain and enhance voice switching capability for flight service stations as expressed in MNS 320.

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[2] This call transfer capability would not enable emergency bypass if a facility were destroyed or substantially damaged by a catastrophic event. However, it could enable bypass if a condition required temporary evacuation of a facility but otherwise allowed the equipment therein to function.

2. BASIS OF INVESTMENT ANALYSIS

2.1 Assumptions and Constraints

The following assumptions and constraints guided the FSS voice switching capability investment analysis:

- The flight service mission will continue, and all 61 AFSSs and (in Alaska) 14 FSSs will remain operational
- No RCOs will be reconnected directly to other FSSs or will be deactivated or added (the existing RCO deployment and connectivity will remain "as is")
- The ACD and VRS at each AFSS were replaced independently[3] of any voice switch acquisition, and their replacement costs were not considered for the FSS voice switching capability investment analysis
- Call transfer will take place at the part-time AFSSs/voice switches and not at some other points along interphone lines or links between AFSSs and RCOs
- Supporting ground telecommunications service for air/ground call transfer will be obtained from an existing telecommunications infrastructure
- Implementation of air/ground call transfer is not dependent on the status and progress of the Operational and Supportability Implementation System (OASIS) program for flight service automation.

This investment analysis was not intended to, and did not, examine the basic flight service mission or consider changes to operational concepts other than part-time operations at some AFSSs that could be enabled by having air/ground call transfer capability at the AFSSs as identified in MNS 320.

Within the FAA, there has been expressed some concern that installation of OASIS at AFSSs is necessary for, and must precede, any implementation of air/ground call transfer. This concern is based on assumptions that the OASIS automation and display capabilities will be necessary to present the additional information, and that the Model 1 Full Capacity (M1FC) system console cannot accommodate the human interface provisions (most likely a touch-entry display), associated with the transferred calls. While OASIS undoubtedly would facilitate some aspects of handling transferred calls, AFSS part-time operations could be implemented using M1FC. Furthermore, panel space on the M1FC consoles dedicated to control and display functions for the Type III ICSS is more than adequate for installation of touch-entry display screens (or other devices) for specialist interface.

The M1F1 console is shown in Figure 2-1. The current ACD/VRS interface is in the upper right corner of the figure. The controls and displays surrounding the lower video screen are for interface with the ICSS.

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[3] Automatic Call Directors and Voice Retrieval Systems were replaced to address year 2000 compatibility concerns.

Figure 2-1. Model 1 Full Capacity System Console
at Automated Flight Service Station

2.2   Requirements for Flight Service Station Voice Switching Capability

Annex I contains the sponsor requirements for FSS voice switching capability that were developed during the course of investment analysis. Major requirements (expressed in terms of an enhanced capability at AFSSs) are highlighted below.

Any enhanced voice switching capability shall:

- Provide all basic functions and features of the current Type III ICSS, including its interface and interoperability with other systems and equipment
- Have the ability to monitor (as initially installed or through modular expansion) up to 200 air/ground and 120 ground/ground communications circuits, with any given circuit being routable to any specialist position via switch supervisor configuration
- Be installable (including any future expansion) within the "footprint" of the current Type III ICSS
- Have the ability to transfer, to another AFSS(s), traffic carried by all air/ground communications circuits and interphone lines physically terminated at the AFSS within which the enhanced capability is installed
- Provide an improved human interface capability with the existing ACD and

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VRS equipment
- Be compatible with current and emerging digital communications technology, techniques, and standards as reflected in the NAS architecture
- Be supportable for at least ten years after installation, including ability to incorporate enhanced technology and functionality on a modular basis.

The primary requirement for voice switching capability at the 14 non-automated FSSs in Alaska is to sustain the functionality provided by the current voice switches in a manner that will be affordable for the next decade.

2.3   Evaluation Criteria

Evaluation criteria considered in recommending an alternative as a solution for FSS voice switching capability were:

- Sustains voice switching capability
- Enables air/ground (and associated interphone) call transfer
- Improves specialist interfaces (voice switch and ACD/VRS)
- Modernizes NAS
- Simplifies logistics support
- Preserves current level of service accessibility as perceptible to flight services customers
- Has acceptable program/technical risk
- Acceptable to operational work force (considering human interface, changes to working conditions, and ease of transition)
- Affordability.

The degree to which a given alternative satisfies these criteria, singly and in combination, is based on judgment of agency stakeholders represented on the investment analysis team. However, the ultimate selection of a solution largely will rest on affordability.

3. CHARACTERIZATION OF TECHNICAL ALTERNATIVES

3.1 Technical Deficiencies of Current Voice Switches at Flight Service Stations

The deficiencies of the current voice switches at AFSSs, and at FSSs in Alaska, against the sponsor's needs and requirements identified in Sections 1 and 2 are presented in Table 3-I. The table also identifies potential solutions to address these deficiencies.

TABLE 3-I. DEFICIENCIES OF FLIGHT SERVICE STATION VOICE SWITCHES

Deficiency	Potential Solution
1. ICSSs at 61 AFSSs nearing end of economic service life	- Extend service life of ICSSs - Replace ICSSs with new voice switches
2. ICSSs have no capability to transfer incoming air/ground and interphone calls	- Add "black box" routers to ICSSs at AFSSs that will transfer calls (i.e., will operate part time) - Replace all ICSSs with new voice switches having call transfer capability
3. ICSSs (including operator interfaces at specialist consoles) have no capacity to accept and display additional (transferred) calls	- Replace ICSSs* with new voice switches at AFSSs that will accept transferred calls (i.e., will operate full time) *Not technically feasible to expand or modify ICSSs
4. No ground telecommunications service in place to transport transferred calls from one AFSS to another	- Procure supporting ground telecommunications service
5. Electromechanical voice switches at 8 of 14 Alaska non-automated FSSs well beyond economic service life (no need for call transfer capability)	- Replace with new voice switches (smaller than voice switches required at AFSSs)

The first three deficiencies listed bound the sets of candidate solutions that can be considered for AFSSs if air/ground and interphone call transfer is to be implemented. These sets are defined as follows.

> Solution Set 1: Replace all ICSSs with new voice switches having call transfer capability (addresses deficiencies 1, 2, and 3)

> Solution Set 2: Replace ICSSs at full-time AFSSs with new voice switches (addresses deficiencies 1 and 3). Extend service life of ICSSs at part-time AFSSs and add "black box" routers to the ICSSs (addresses deficiencies 1 and 2).

The solution sets are illustrated in Figure 3-1. An assessment of these solution sets against the first six evaluation criteria of 2.3 is shown in Table 3-II (the remaining three criteria are more sensitive to specific alternatives).

Service-life extension of all ICSSs is not a viable component of any solution that provides call transfer capability because of deficiency 3. Notwithstanding, such service-life extension will be addressed as a "reference case" for judging candidate solutions involving replacement voice switches at some or all AFSSs.
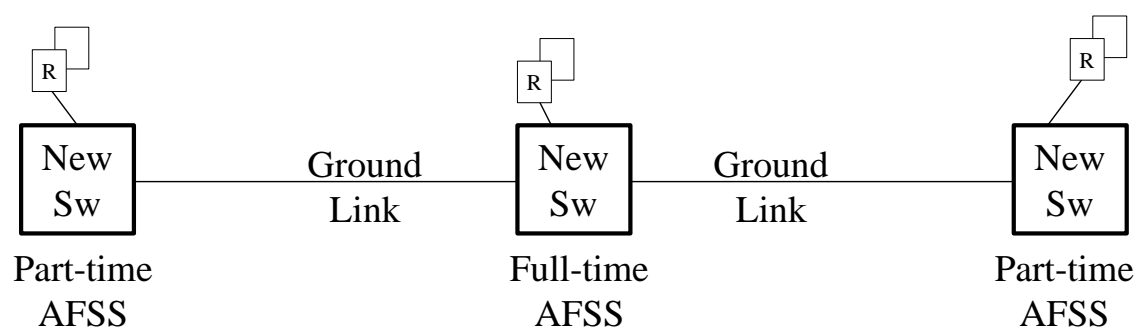
1: Replace All ICSSs
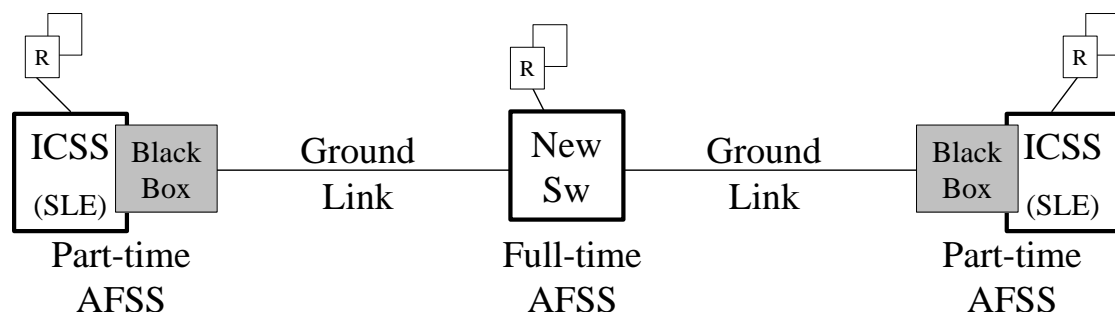
**2: Replace ICSSs at Full-time AFSSs and Install Call
Transfer Black Boxes at Part-time AFSSs**

Figure 3-1. Solution Sets That Enable Air/Ground Call Transfer

TABLE 3-II. EVALUATION OF SOLUTION SETS

Evaluation Criterion	Solution Set		Reference Case
	1. Replacement Switches Everywhere	2. Replacement Switches, ICSSs, and Black Boxes	Service Life Extension of All ICSSs
Sustains voice switching capability	Yes	Yes	Yes
Enables air/ground call transfer	Yes	Yes[a]	No
Improves specialist interfaces	Yes	Partial[b]	No
Modernizes NAS	Yes	Partial[b]	No
Simplifies logistics support	Yes	No	No
Preserves user service accessibility	Yes	Yes[c]	Yes[c]

NOTES:

a. Equipment installation "freezes" initial selections of full-time and part-time AFSSs

b. Criterion satisfied only at AFSSs receiving replacement voice switches

c. Future service may be degraded by equipment failures if cost of ICSS support becomes prohibitive

Although not stated in MNS 320 as part of the need, the sponsor implicitly assumed the ability to define (and redefine) call-transfer clusters on an operational basis, and to designate any AFSS within a cluster as the full-time AFSS. Accordingly, the solution set involving black boxes is perceived as less desirable than alternatives that do not introduce technological constraints on determinations of clusters and full-time AFSSs. Furthermore, any solution involving a mix of replacement voice switches, ICSSs, and black boxes imposes an additional logistics burden and provides unequal capabilities for specialists at different AFSSs, possibly leading to work force dissatisfaction.

3.2   Service Life Extension of Current Voice Switches

3.2.1   Status of Current Voice Switches

The current AFSS voice switches are Type III Integrated Communications Switching System (ICSS), manufactured by Litton and Denro. In 1982, the FAA contracted with Litton for delivery of 31 Type III ICSSs and, in 1984, with Denro for 15 Type III ICSSs. In December 1988, the FAA contracted with Denro for delivery of another 17 Type III ICSSs manufactured to an upgraded "Phase 1A" production baseline (the 15 Denro ICSSs acquired in 1984 were identified as "Phase 1"). In September 1993, Denro was awarded a three-year contract to upgrade the 15 Phase 1 switches to the Phase 1A baseline.

The Litton and Denro ICSSs handle communications traffic in analog form and employ eight-bit, first-generation microprocessors that are obsolete[4]. Peripheral equipment includes obsolete disk and tape drives that are inordinately costly to repair or replace.

The Litton ICSSs currently are supported by the FAA at site level and by Litton at depot level under a ten-year, fixed-price contract (with economic price adjustment) that expires in June 2002. The Denro ICSSs were supported in a similar manner, but, in 1996, the FAA assumed depot support responsibility for these switches (the necessary data, equipment, and parts were obtained from Denro). The Litton support contract includes no options for providing the FAA with depot-level technical data, tools, test equipment, or spare parts, and the agency would be unable to assume depot support responsibilities for the Litton ICSSs without purchasing these items at an additional, negotiated price.

At the Alaska FSSs, the GRM Corporation Model 8165 electromechanical voice switches no longer are supported by the FAA, and field-expedient means[5] are used to keep these switches operational. STVSs (which have a large installed base in towers) will be supported by the FAA for at least the next decade.

3.2.2   Advantages and Feasibility of Service Life Extension

There are several generic advantages to sustaining any operational system or equipment (assuming that it can remain capable of satisfying its essential functional requirements). These advantages include:

- Continuation of familiar operational processes and procedures
- No disruption resulting from installation of new equipment and removal of old equipment, and no period of operational transition during which quality of service provided to customers may experience degradation
- Avoidance of substantial initial cost associated with new equipment

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[4] Similar Type II ICSS switches, installed at airport traffic control towers and terminal radar approach control facilities, are being replaced with digital voice switches under the FAA's Enhanced Terminal Voice Switch program over a seven-year period that began in 1997.

[5] A technician first will check the Logistics Center, then other operational sites, to determine if a replacement for a failed part exists. If unsuccessful, the technician then will attempt to improvise a solution using whatever suitable materials may be available.

acquisition (even though ultimate lifecycle cost may be lower).

The Litton and Denro ICSSs functionally are capable of enabling continuation of flight service provision in its present form. The air/ground radios at RCOs will remain analog for several years. Without air/ground call transfer, switch interfaces with ground telecommunications infrastructure will comprise terminations of dedicated voice-grade interphone lines from other air traffic control facilities and subscriber-level circuits from commercial networks. These also will be supportable in analog form for the foreseeable future.

Analysis of operational data for the Litton and Denro ICSSs, combined with other available information, indicates the technical feasibility of supporting both switches for the next several years as a minimum. Thus, service-life extension is a realistic alternative to continue current AFSS voice switching capability, and an immediate decision regarding a program for enhancement rests principally on affordability, on the urgency of implementing AFSS part-time operations, and on a desire to proceed with NAS modernization in the voice switching arena.

Because the eight electromechanical voice switches at Alaska FSSs are technological "orphans", it is not viable to assume a continuing capability to sustain their functionality for an extended period of time.

3.2.3 Disadvantages and Risks of Service Life Extension

The disadvantages of service life extension for all current AFSS voice switches are:

- Uncertainty regarding how long (beyond the next several years) it will be economically feasible to sustain the Litton and Denro ICSSs at the 61 AFSSs
- Inability to implement air/ground call transfer to realize increased flight service staff utilization efficiency from part-time operations of some AFSSs
- Failure to capitalize on better accuracy and greater efficiency in performance of functions by air traffic control specialists and switch maintainers that would be enabled by modern hardware and software capabilities and design
- Failure to support modernization of flight services and NAS voice switching as described in the NAS architecture.

The factor posing the greatest risk is the first, the uncertainty of sustainability (the other factors pose operational penalties but not risks *per se*). It is possible that non-reparable critical failures of ICSSs could force closures of AFSSs, necessitating consolidations of their functions (or closures of other facilities from which working ICSSs would be canibalized to repair the failed switches) or could force piecemeal "emergency" acquisitions of replacement switches that might or might not be well suited to perform flight service voice switching functions. More likely are increasing failures that would result in service outages, degrading the overall level of service provided to airspace users.

The impact of uncertain sustainability is reflected in the lifecycle cost estimate of Section 4.

3.2.4 Definition of Reference Case

A "reference case" establishes the basis for estimating lifecycle economic and operational benefits of providing an existing capability or service in alternative ways. The reference case often is "status quo" (sometimes called "do nothing", a misnomer); i.e., continuing to provide the capability or service for a specified number of years in the same manner as it currently is provided. However, the reference case must consider the impacts of the following if applicable:

- Planned modifications to current system hardware and/or software
- Planned changes to current operational procedures
- Beneficial modifications/changes that, although not planned, could be implemented within the realm of operational management's discretion and budget authority (i.e., that do not require approval of the JRC or any other agency-level management body).

A degree of subjectivity often is required in deciding whether a hypothetical modification or change would constitute a managerial prerogative and therefore should be used in defining a reference case that could enhance the *status quo*. After comparisons of candidate alternatives to such a hypothetical reference case (sometimes called a "non-material solution"), the latter may emerge as the preferred solution.

For AFSS voice switching capability, the reference case, comprising service-life extension of the Litton and Denro ICSSs, has been defined as *status quo*; continued depot-level support of the Denro ICSSs in-house and of the Litton ICSSs via contract. Transition to in-house depot-level support of the Litton switches was considered as an option for the reference case, but analysis indicated that the costs of renewing the support contract over the period of service-life extension would be less than the lifecycle costs for in-house support. There is, however, an element of risk in this conclusion because of uncertainty regarding the contractor's assessment of future profitability in continuing to provide support.

Since the eight electromechanical voice switches at Alaska FSSs no longer receive depot support from the FAA Logistics Center, there is no credible data from which to develop a reference case.

3.3   Alternatives for Enhancement of Voice Switching Capability

Two voice switches were considered as replacements for ICSSs currently at AFSSs. They are:

- Voice Switch Replacement System (VSRS)
- Enhanced Terminal Voice Switch (ETVS)[6]

The VSRS (the designation is taken from NAS Architecture 4.0, as discussed in 3.3.7) is a commercial or non-developmental item (NDI) voice switch designed and manufactured using contemporary concepts, technology, and practices for communications switching systems (such as modularity, scalability, and conformance to open standards). It would include (or be modified

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[6] The principal reason for consideration of the ETVS is its availability through the current Litton contract. Other terminal voice switches that recently have been acquired by the FAA are the Rapid Deployment Voice Switch (RDVS) and the STVS. The RDVS contract is intended for small-quantity purchases, and its terms and conditions render it unsuitable to address AFSS voice switch requirements. The STVS, although currently available, is too small for use in AFSSs.

to include) the air/ground call transfer capability needed to implement AFSS part-time operations and would utilize a touch-entry display (TED) for operator interface (as do nearly all new voice switches) that could be adapted to accommodate the requirements of the flight service interface, and the ACD/VRS interface as well.

During the spring and summer of 1999, members of the investment analysis team met with several vendors of voice switching technology and established that switches are available in the commercial and government arenas that could be suitably modified[7]. Thus, the VSRS could be acquired through full and open competition.

The ETVS currently is installed in larger airport traffic control towers and terminal radar approach control facilities. The ETVS design is based on mid-1990s technology and is available via contract with Litton through 2004. Although a digital switch, it is designed to interface only with analog communications circuits. As a terminal switch, it does not include the capabilities needed to accomplish call transfer, and both its hardware and software would have to be modified for that purpose. The ETVS uses a TED for operator interface that could be modified for flight service and ACD/VRS interface functions. The Litton contract includes depot maintenance support that extends into 2007.

As described in 3.1, one solution set for enhancing AFSS voice switching capability (in particular, for providing air/ground call transfer capability) involves the replacement of ICSSs with new voice switches at some AFSSs, and the addition of call transfer "black boxes" to the ICSSs at other AFSSs. The new switch for this solution set, which would not require call transfer capability, could be either a "VSRS" or an ETVS. However, the black box itself would require development, which, for practical purposes, would be accomplished by the contractor providing the voice switch. For the ETVS in particular, the scope of effort to provide the switch and develop a separate call transfer black box would be similar to the scope of effort to modify the switch itself to include call transfer capability.

3.3.1   Implementation Alternatives

Based on the above, the following implementation alternatives to enhance voice switching capability at AFSSs were defined.

> Solution Set 1: Replace all ICSSs with new voice switches having call transfer capability
>
> > 1.a. Use VSRSs (with call transfer capability) at all AFSSs
> > 1.b. Use ETVSs, modified to include call transfer capability, at all AFSSs
>
> Solution Set 2: Replace ICSSs at full-time AFSSs with new voice switches. Extend service life of ICSSs at part-time AFSSs and add "black box" routers to the ICSSs
>
> > 2.a. Use VSRSs (no need for call transfer capability) at full-time AFSSs

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[7] Vendors participating in the market survey are identified in Annex II.

2.b. Use ETVSs at full-time AFSSs

For all cases of replacement voice switches (whether including call transfer capability or not), nonrecurring engineering will be required to modify the TED to accommodate the flight service and ACD/VRS interface functions.

3.3.2 Common Factors

For any of the implementation alternatives, there are several factors that must be considered, all resulting in "additional" costs for enhancement of voice switching capability at the 61 AFSSs. These are as follows:

- The "cluster" scenario used to estimate the economic benefit of call transfer (described in 4.5.1) includes part-time AFSSs having both Litton and Denro ICSSs. Implementation of either "black box" alternative as described thus would leave both types of ICSS in use while adding a third type of voice switch (VSRS or ETVS) to perform flight service voice switching. Accordingly, for either "black box" alternative, all Litton ICSSs (whether at full-time or part-time AFSSs) will be replaced, since the Litton ICSSs pose the greater risk in ICSS sustainability, leaving only the Denro ICSSs in use
- For either type of replacement voice switch (and black box) installation, AFSS facilities will require upgrades (some more than others) to accept the newer technology
- For either type of replacement voice switch (and black box), RMM capability and telecommunications will be required (NAS architecture imperative)
- For either type of replacement voice switch (and black box), information security (INFOSEC) capabilities and features will be required (NAS architecture imperative). These capabilities and features presently are undefined (3.3.6 discusses INFOSEC in more detail)
- At AFSSs receiving replacement voice switches (VSRS or ETVS), OASIS consoles must be modified to accept TEDs (OASIS consoles currently are designed to accommodate controls and displays of the ICSS)[8]
- The Aeronautical Center and Technical Center require four "glass case" switching systems (ETVS or VSRS, with black boxes as appropriate) for maintenance, training, and testing.

These factors have been included in developing the lifecycle cost estimates for the implementation alternatives.

3.3.3 Acquisition and Installation of Voice Switch Replacement System

As stated in 3.3, discussions with vendors of voice switching technology have indicated that a

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[8] Full-scale manufacture of OASIS consoles has not yet begun, and there exists an opportunity to redesign the console panels to accept the TED of a replacement voice switch (VSRS or ETVS) with only a nonrecurring cost. The OASIS program office will not make any change to the console contract until a program for AFSS voice switching capability enhancement is established. If console manufacturing and deployment commence before the panels are redesigned, there will be a considerably larger recurring cost for modification.

switch satisfying the sponsor's requirements can be acquired as a modified commercial product via full and open competition. Some nonrecurring engineering will be necessary to provide transfer capability for air/ground calls (either within the switch itself or as an external "black box" device) and to modify the TED to accommodate the flight service and ACD/VRS interface functions for computer-human interface (CHI). However, most of the switch modules would be NDIs.

The basic strategy for installation (after the modified switch design has been tested thoroughly to satisfy contract specifications) is to replace the Litton ICSSs first, followed by the Denro ICSSs. The specific sequence of installations for AFSSs will be coordinated with Air Traffic to enable air/ground call transfer and part-time operations to commence as early as practical. The four "glass case" switching systems will be provided to the Aeronautical Center and Technical Center during the period of Litton ICSS replacement.

Because replacement of Litton ICSSs cannot be completed before June 2002, it will be necessary to extend the Litton depot maintenance support contract to cover the period of VSRS installation. If black boxes are being installed at part-time AFSSs, only those Denro ICSSs at full-time AFSSs within clusters will be replaced. Denro ICSSs at any AFSSs that are not in clusters (and thus do not participate in air/ground call transfer) will not receive black boxes.

The distribution of equipment described above for the two alternatives involving VSRSs (1.a. and 2.a.) is shown in Table 3-III.

TABLE 3-III. AFSS EQUIPAGE FOR VSRS ALTERNATIVES

Implementation Alternative	AFSS Having Litton ICSS			AFSS Having Denro ICSS		
	FT/Cluster	PT/Cluster	Non-cluster	FT/Cluster	PT/Cluster	Non-cluster
1.a.	VSRS	VSRS	VSRS	VSRS	VSRS	VSRS
2.a.	VSRS	VSRS + BB	VSRS	VSRS	Denro + BB	Denro

3.3.4 Installation of Enhanced Terminal Voice Switch

Acquisition and installation of ETVSs as replacement voice switches at AFSSs would be highly similar to acquisition and installation of VSRSs (with or without black boxes). The principal perceived advantage of this approach is use of the current ETVS contract with Litton, thus saving potentially as much as a year in solution implementation compared to conducting a full and open competition for the VSRS.

However, the extent of modification required to include call transfer capability (either as part of the ETVS itself or as a black box), and to incorporate the flight service and ACD/VRS interface functions in the TED, might lead to vendor protest(s) on the basis that the effort is beyond the scope of the current contract. Such protest(s) could negate the schedule advantage of a single-source award.

It also is likely that funding would not be available to support an accelerated schedule. Because acquisition authority under the contract expires in 2004, there likely would not be sufficient time to install switches at all AFSSs (or even switches and black boxes at most AFSSs) without a

contract extension (further increasing the likelihood of protest). Accordingly, commitment to ETVSs as replacement voice switches is considered to pose a medium-to-high risk to program success.

Another advantage of the ETVS (when replacing the ICSSs at all 61 AFSSs) is that, beyond simplifying logistics support by consolidating two types of flight service voice switch to a single type, there is an installed base of ETVSs throughout the NAS. However, depot maintenance support under the Litton contract expires in 2007 (at which time the ETVS technology will be more than ten years old), resulting in a situation analogous to the one that the agency faces with the Litton ICSSs. It also is noted that Denro ICSSs currently at the Aeronautical and Technical Centers would remain in addition to the glass-case new switching systems to be installed.

3.3.5   Human Factors

Several human factors issues regarding provision of flight services have been identified during the course of the investment analysis, in large part due to active participation by the National Association of Air Traffic Specialists on the investment analysis team. The principal issue is one of CHI with a replacement voice switch. Contemporary voice switches commonly use TEDs for CHI to conduct normal switch operations. The design of a TED involves technical considerations such as color, contrast, resolution, visibility in ambient lighting, and sizes and shapes of characters and icons. It also involves operational and "cultural" considerations relating to the types of functions to be performed and how those functions previously have been accomplished by the work force. In short, a successful design requires the ongoing collaboration of human factors experts and personnel with operational experience who can provide insights and feedback on evolving prototype designs.

Members of the investment analysis team have examined TEDs for current FAA voice switches in detail to identify aspects that should be addressed in the AFSS voice switch requirements document and to determine the likelihood of any significant human factors risks. No such risks have been identified at this time, although some concerns have been noted. One involves the display of information on the status of switch line terminations. Since a TED that could be installed in or on a specialist console (either OASIS or M1FC) would not be large enough to present status information on all RCO sites and interphone lines simultaneously (including those transferred for part-time operations), a method must be designed to display them in a logical and efficient manner for use by the work force. This is an example of the type of human factors concern that, once recognized, poses little technical risk and usually can be addressed in a straightforward manner. It is only when not recognized in a timely manner that such a concern may become a significant risk to a program's planned cost and schedule.

Another concern is the integration of CHI for the ACD and VRS with CHI for the voice switch. Air traffic control specialists have articulated several shortcomings of the current ACD and VRS interfaces (in particular, at a nationwide meeting held in Dallas, Texas in November 1999). It subsequently was agreed that enhancements of these interfaces will be accomplished as part of any program acquiring AFSS replacement voice switches. This integration may pose a medium technical risk in that additional control and display functions must be accommodated on the TED. However, it is better to recognize such a need in the beginning than to attempt retrofit of the requirement after the CHI design is underway.

Physical placement of the TED on the specialist console (whether OASIS or M1FC) is a human factors concern. Either console must be modified (OASIS consoles currently are designed for the controls and displays of the Type III ICSS) to accept the TED, and failure to recognize some aspect of viewability or accessibility before modification is undertaken could become a costly oversight. Coordination discussions with the OASIS program office have been initiated, and this risk is assessed as low.

There also are human factors considerations in the transfer of air/ground calls to implement part-time operations of some AFSSs. These involve not only the TED concerns previously identified but also introduction of new procedures and handling of increased workload. Risk in this area can be mitigated by ongoing involvement of the specialist work force in development of new procedures, and by introduction of part-time operations in a controlled manner after thorough operational test of air/ground call transfer. There is low risk that air/ground call transfer could not be integrated successfully into flight service operations.

Table 3-IV provides a summary of the human factors issues, risks, and mitigation strategies for an AFSS voice switch acquisition program.

TABLE 3-IV. HUMAN FACTORS ISSUES AND RISKS

Issue	Risk and Approach/Mitigation Strategy
TED design and layout	Low: Collaboration of human factors experts and operational personnel
Integration of flight service and ACD/VRS CHI	Medium: Fallback is no integration of ACD/VRS CHI
Installation of TED in/on specialist console	Low: Collaboration of engineers, human factors experts, and operational personnel
Incorporation of air/ground call transfer in flight services operations	Low: Collaboration with operational personnel in procedure development and thorough operational test

3.3.6   REDACTED

3.3.7   Compatibility with Architecture

In Version 4.0 of the FAA's NAS architecture [Ref. 4], voice switching capability for flight services is addressed principally in Section 17, *Communications* and Section 25, *Flight Services*. Table 3-VI characterizes the current NAS, and synopsizes the architecture's modernization roadmap, with regard to voice switches, ground telecommunications, and provision of flight services. An objective of the architecture is to "modernize [flight services] communications while retaining in-flight voice services and associated infrastructure as a governmental function."

The replacement voice switch envisioned for AFSSs aligns with the architecture's modernization roadmap. The switch (reflecting contemporary commercial voice switching concepts, technology, and practices) will be completely digital, including digital interfaces on both the line and equipment sides; will be capable of call forwarding, in order to perform the air/ground and associated interphone call transfer function; and will provide call supervision, a capability needed to enable call transfer (and intrinsically accomplished via common-channel signaling in an all-digital environment). With minor enhancements to the capabilities already required to satisfy MNS 320, the AFSS replacement voice switch can become the Voice Switch Replacement System identified by the architecture for NAS-wide implementation during Modernization Phase 3.

TABLE 3-VI. NAS ARCHITECTURE 4.0 MODERNIZATION ROADMAP FOR FLIGHT SERVICES

Time Frame	Voice Switches	Telecommunications	Flight Services Provision
Current (Modernization Phase 1)	Analog interfaces for terminal equipment and circuits	25000 interfacility point-to-point circuits, most digital	61 AFSSs with Model 1 Full Capacity (M1FC) flight service automation
	No call forwarding; in-band or no supervisory signaling		
Through 2005/8 (Modernization Phase 2)	Transition to digital interfaces and out-of-band/common-channel signaling	Transition to switched/ common-user network providing bandwidth-on-demand	M1FC replaced by OASIS
			Increasing pilot self-reliance for preflight services and greater emphasis on specialist provision of in-flight services
2006/9 – 2015 (Modernization Phase 3)	Transition to all-digital Voice Switch Replacement System scalable for use throughout NAS	NAS-wide information network interconnects air traffic control facilities, databases, and NAS users	Transition from voice to data for provision of in-flight services (dependent on user equipage)
			OASIS upgraded to provide enhanced flight-planning functions

The ETVS, which currently has an installed base within the NAS, is one of the voice switches that is envisioned to be replaced during Modernization Phase 3 of the NAS architecture. Thus, the ETVS can be viewed as a "future legacy" voice switch that represents the characteristics of Modernization Phase 1, and its installation during the closing years of Modernization Phase 2 would not appear to represent the best use of the agency's capital funds.

3.3.8   Solution for Alaska Flight Service Stations

Because the electromechanical voice switches in six of the 14 Alaska FSSs already have been replaced with STVSs, the most cost-effective and operationally advantageous solution is to replace the remaining eight electromechanical voice switches with STVSs. This can be done quickly under the current STVS contract with Litton.

3.4   Role of Ground Telecommunications Service

To implement part-time operations at some AFSSs, it is necessary to obtain service from a ground telecommunications infrastructure to transport communications traffic associated with the RCOs and interphone lines connected to those (part-time) AFSSs to other (full-time) AFSSs. This investment analysis considered three facets of a ground telecommunications service:

- Technical feasibility of transporting half-duplex (push-to-talk) air/ground communications traffic via a switched, full-duplex telecommunications network
- Availability of FAA-owned or -controlled ground telecommunications assets that could provide suitable service (in terms of bandwidth, quality, and presence at subscriber locations)
- Annual costs of service and any non-recurring costs to establish connection.

It was determined that agency ground telecommunications assets currently are available, and will be available in the future, to support air/ground call transfer. Technical feasibility also was ascertained (Appendix B presents relevant considerations). The operational architecture that was used to model air/ground call transfer, and thus provide the basis for estimating telecommunications costs, is described in 4.5.1. That architecture comprises clusters of geographically-proximate AFSSs, with one of the AFSSs in each cluster serving as the full-time facility to which the part-time AFSSs transfer their air/ground calls during those periods when they are not operational. The AFSSs within a cluster are interconnected by dedicated T1 links.

In the latter part of the decade, the agency plans to implement the FAA Telecommunications Infrastructure (FTI), a switched, common-user network for voice and data, to replace many of the long-haul, point-to-point transmission systems and circuits currently in use throughout the NAS. FTI will transport information in digital form, although users (at least initially) will be able to present and receive information in analog as well as digital format at FTI interface points.

For this investment analysis, FTI was not considered as a means of obtaining the ground telecommunications service necessary to enable air/ground call transfer, since it is not projected to be available for flight services use until several years after enhanced voice switching capability is fielded at AFSSs. At present, any estimate of a cost advantage that FTI then might provide over the cost of currently-available telecommunications service would be conjectural. The principal reason for addressing FTI in this report is to note that it offers the possibility of allowing air/ground call transfer without the need for call transfer capability at the AFSSs (although new voice switches still would be required at AFSSs receiving transferred calls). In lieu of "hard wiring" RCOs to specific AFSSs (as is now the case), RCOs could be connected to FTI access points and then routed to any AFSS desired through the network.

4.Comparison of Alternatives

4.1 Lifecycle Cost of Reference Case

     Redacted

4.2 Installation of Small Tower Voice Switches for Alaska

     Redacted

4.3 Total Costs of Implementation Alternatives

     Redacted

4.4 Lifecycle Cost of Voice Switch Replacement System

     Redacted

4.5 Benefits

Table 4-IV categorizes the benefits that would arise from replacement of the 1980s-vintage ICSSs at all AFSSs with VSRSs employing modern technology and based on open standards. As noted, all benefits accrue to the FAA.

TABLE 4-IV. BENEFIT CATEGORIES FOR REPLACEMENT VOICE SWITCHES
AT ALL AFSSs

Benefit Category	Benefit Description	Beneficiary
1. Efficiency of service delivery	Increased flight service staff utilization efficiency enabled by air/ground call transfer	FAA
2. Infrastructure modernization	Support cost avoidance (in comparison to continued use of ICSSs) plus NAS architecture compatibility and INFOSEC capability	FAA
3. Intangible	Identifiable benefits that have not been quantified because of difficulty and/or minor contribution to overall benefit	FAA

The reference case, service life extension of all ICSSs, provides the basis for estimating benefits of alternatives. The sponsor's intent is to maintain the current method and level of service delivery as perceived by users of flight services (principally general aviation), so replacement of ICSSs and implementation of air/ground call transfer and part-time operations at some AFSSs essentially would be transparent to the users.

(Tables 4-I and 4-III have been redacted.)

4.5.1   Increased Staff Utilization Efficiency

Implementation of air/ground call transfer will enable (1) some AFSSs to be non-operational during daily periods of low demand (i.e., to operate part time), and (2) dynamic workload balancing while all AFSSs are in operation. Both provide more flexibility to match existing flight service staff resources with time- and geographically-sensitive demand. This increased staff utilization efficiency will allow continued delivery of the current level of flight services to users in the face of decreasing staff resources due to attrition (budget constraints may not allow all departing staff to be replaced).

Staffing Model. The approach for quantifying the benefit of increased staff utilization efficiency involved calculations and comparisons, by ATX-330, of flight service staffing required to meet air/ground service workloads for "clusters" of two - four AFSSs (1) when call transfer is used within the clusters, and (2) when call transfer is not available (the base-case staffing). Benefit accrues from a reduction in staffing to handle cluster workloads when call transfer is used. Nineteen clusters were defined, based approximately on the AFSSs within ARTCC areas of the contiguous U.S. The AFSSs in Puerto Rico, Hawaii, and Alaska were excluded, as was the AFSS in Miami, because clusters including these AFSSs would not be practical.

For each cluster, analyses were done for a hypothetical mid-shift period (2400 – 0600 local time) and a 24-hour period[9]. ATX-330 performed the analyses by applying its AFSS daily staffing model, modified to address the AFSS clusters as well as individual AFSSs, to daily operational data samples obtained for each AFSS over the course of a year.

Results. Table 4-V shows results for the mid-shift and 24-hour periods as <u>differences</u> between the base-case staffing and the staffing that would be required for cluster workloads if call transfer were used (actual AFSS daily staffing levels are not shown in the table). For each cluster, the results are considered statistically significant when the end points of the 95% confidence intervals do not have opposite signs. Applying the staffing adjustment factor of 1.76 (see Note 4 of the table), the results indicate a theoretical saving of approximately 40 flight service specialists for mid-shift operations and of approximately 600 flight service specialists if workload were aggregated on a continuous basis.

These values are representative rather than definitive, because there are many practical factors that would bear on implementation of workload aggregation via call transfer. Since the intention was to obtain estimates, rather than accurate determinations, of staff reductions, ATX-330 did not optimize mid-shift timing by facility (which accounts for the clusters that showed staff increases from using call transfer). Also, it is quite likely that more detailed analysis of traffic patterns would lead to different cluster definitions and greater staff utilization efficiencies.

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[9] The clusters and periods used to analyze the flight service staffing impacts of air/ground call transfer were chosen by ATX-330 as representative for purposes of the investment analysis and should not be construed to signify a particular intent of the Air Traffic Service.

Economic Benefit. Using an average annual cost of $75k per non-supervisory specialist, the total savings will range between:

- Mid-shift only workload transfer $3M per year (lower bound)
- Continuous workload aggregation $45M per year (upper bound)

TABLE 4-V. REDUCTIONS IN DAILY STAFFING ENABLED BY AIR/GROUND CALL TRANSFER WITHIN AFSS CLUSTERS

AFSS Clusters	Mid-shift Period: Base-case Staffing Minus Staffing Using Call Transfer			24-hour Period: Base-case Staffing Minus Staffing Using Call Transfer		
	Mean Staffing Difference	95% Confidence Interval		Mean Staffing Difference	95% Confidence Interval	
ABQ, PRC	-0.13	-0.61	0.36	8.13	7.51	8.74
BDR, BTV, BGR	2.05	1.12	2.98	21.10	20.26	21.94
CDC, BOI, GTF	2.18	1.38	2.99	18.43	17.81	19.06
CLE, BUF, AOO	1.39	0.44	2.34	19.65	19.01	20.30
COU, ICT, STL	0.09	-0.75	0.92	17.78	16.87	18.69
DCA, EKN, RDU	2.74	1.77	3.71	23.13	22.20	24.06
DEN, CPR	1.39	0.74	2.04	9.91	9.19	10.64
FTW, MLC	1.25	0.80	1.70	9.42	8.63	10.20
GNV, PIE	0.17	-0.62	0.95	9.88	9.08	10.67
HHR, RAL, SAN	2.71	1.76	3.66	19.63	18.45	20.80
HUF, LOU, DAY	2.04	1.12	2.96	19.83	19.00	20.67
IKK, FOD, GRB, LAN	-1.90	-3.75	-0.05	24.30	22.77	25.83
ISP, IPT, MIV	1.29	0.28	2.29	21.00	20.15	21.85
MCN, ANB, AND	0.86	0.01	1.72	17.27	16.52	18.02
MKL, JBR, GWO, BNA	1.36	0.38	2.35	28.91	28.20	29.62
OAK, RIU, RNO	0.38	-0.44	1.20	18.62	17.95	19.29
PNM, GFK, HON, OLU	3.58	2.57	4.59	29.53	28.05	31.00
SEA, MMV	1.92	1.44	2.40	9.58	8.88	10.29
SJT, CXO, DRI	0.43	-0.72	1.59	19.09	18.09	20.08
Total (excluding gray values)	22.86			345.18		

NOTES:

1. Locations of individual AFSSs are indicated in Figure 1-1.
2. Positive staffing difference values represent decreases in daily staffing. Negative values indicate increases.
3. Gray indicates that the mean staffing difference is not statistically significant, based on the 95% confidence interval. Statistically insignificant values are excluded from the totals.
4. Daily staffing difference totals must be multiplied by the model's staffing adjustment factor of 1.76 to obtain the annual staffing differences represented. This factor accounts for seven-day-per-week AFSS operation and specialist off-position activities (e.g., leave and training).

The values are given in FY 2000 dollars. Actual cost savings will depend on the strategy and timing for implementation of AFSS part-time operations, as determined by Air Traffic in conjunction with the National Association of Air Traffic Specialists. Because staffing at many AFSSs is below that indicated by the staffing standards, staff "saved" through part-time operations will be "reinvested" (redeployed) to improve service delivery to users by alleviating shortages at these facilities. As of January 2000, the total shortage was 303 specialists.

Air/ground call transfer capability also will allow some reductions in the following types of operating expenses:

- Night differential pay for AFSSs at which night workload substantially is below the service delivery capacity of the required minimum staffing
- Overtime pay for AFSSs that are understaffed for local workload
- Charges for electrical power used by AFSSs that operate part time.

These reductions are not sufficiently great to attempt quantification.

4.5.2   Net Benefit

Support Cost Avoidance.   Table 4-II shows that, over the lifecycle, support costs for the preferred alternative are more than $30M lower than the support costs of the reference case (these support costs are presented explicitly in Table 5-III).   Thus, the preferred alternative justifies modernization in that regard.

Air/Ground Call Transfer.   The parameter used as a formal measure of benefit for enhancement of FSS voice switching capability is the annual cost avoidance of increased utilization efficiency of flight service staff resources that is enabled by air/ground call transfer.   A benefit threshold for the program is determined by setting FY 2019, the assumed end of the lifecycle for AFSS replacement voice switching systems, as the year to complete amortization of the capital investment to acquire FSS replacement voice switches (including the STVSs at Alaska FSSs, for which benefit is not quantified).   The capital investment is represented by the F&E cost incurred during FY 2000 – FY 2009, the period of solution implementation.   This cost totals $103.0M in current dollars, and the present value is $64.3M in FY 2000 dollars, using a discount rate of 7%.

Air/ground call transfer is assumed to begin on a trial basis in FY 2004 and to increase at a rate commensurate with the increasing annual cost of the supporting telecommunications service. Full implementation is assumed to begin in FY 2011 and to continue throughout the period of in-service management.   To complete amortization in FY2019, the annual value of cost avoidance benefit that must be maintained is $17.4M in FY 2000 dollars.   This accounts for the recurring cost of the supporting telecommunications service.

Table 4-VI compares various levels of lifecycle cost avoidance from air/ground call transfer implementation in terms of their net present values.   The table also shows the present value of the capital investment for FSS replacement voice switches for reference.

As indicated previously, the annual cost avoidance attributable to air/ground call transfer is highly dependent on the degree (between mid-shift only and continuous) to which Air Traffic chooses to implement workload aggregation.   For annual cost-avoidance values beyond the "baseline" value of $17.4M, and for more rapid implementation, net benefit will accrue quickly during in-service management.

TABLE 4-VI. COMPARISON OF LIFECYCLE COST AVOIDANCE LEVELS

Gross Annual Cost Avoidance (FY00 $M OPS)	Net Present Value* ($M through FY19)	Benefit/Cost Ratio Through FY19 (NPV/F&E)
3.0 (mid-shift only)	2.5	0.04
12.0	41.1	0.64
17.4 (baseline value)	64.3	1.00
23.0	88.3	1.37
33.0	131.3	2.04
45.0 (continuous)	182.8	2.84

Solution imp. F&E	64.3

*Accounts for annual cost of ground telecommunications service

4.5.3   Qualitative Benefits

In addition to the above, there are several benefits attributable to the modern technology that will comprise any replacement voice switching system. It is difficult and not worthwhile to quantify these benefits, as they are deemed of minor significance to the outcome of the investment analysis, but they clearly have value and therefore are identified.

- *Smaller size*. A replacement switch (including its controls and displays) will be smaller than the current switch, thus potentially freeing floor space in the equipment room and panel space on the specialist console for other use
- *Lower power consumption*. While this contributes to reduced operating cost of the replacement switch, lower power consumption also will produce less heat and thus place less demand on a facility's cooling system (conversely, greater demand may be placed on a facility's heating system during cold weather)
- *Improved human factors*. Examination by flight service specialists of touch-entry display (TED) screens and other computer-human interface aspects of Hughes Technical Center glass-case models of small switches currently being acquired by the FAA indicates that specialist performance of operational functions involving the replacement switch should be enhanced. In particular,
  - Intrinsic accessibility of TED screens to wheelchair-confined specialists will obviate the need to modify consoles for disabled access
  - After an airborne transmission has ceased, indication of the RCO activated will remain on a TED screen, allowing a specialist to respond immediately via the appropriate frequency without remembering a pilot's verbal identification of the RCO (if such identification even was provided). Over time, users may recognize a general reduction in waits for responses
- *Continuing interoperability*. A replacement switch will reflect a modular design based on open standards, enabling it better to maintain compatibility and interoperability with emerging telecommunications technology and

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techniques in the context of overall NAS modernization.

5.   RECOMMENDATION

5.1   Technical Solution and Program Strategy

The recommended technical solution for sustaining flight service station voice switching capability comprises:

- Installation of VSRSs with call transfer capability at all 61 AFSSs (plus four additional systems at the Aeronautical Center and Technical Center)
- Installation of STVSs at the eight non-automated FSSs in Alaska that still have electromechanical voice switches (six others currently have STVSs)

The advantages of the recommended technical solution are:

- Air/ground call transfer capability (in conjunction with supporting ground telecommunications service) will enable AFSS part-time operations
- Modernization of AFSS voice switching capability (including INFOSEC) in accordance with the plan of the NAS architecture, with potential to provide the architecture's envisioned common platform for NAS-wide voice switching
- Simplification of maintenance by
    - Replacing the current two versions of AFSS voice switches with switches from a single vendor
    - Incorporation of RMM capability in the switches
- Cost-effective approach (in both acquisition and lifecycle maintenance) to sustaining voice switching capability at Alaska FSSs

Implementation of the recommended technical solution will take place in two phases, as follows:

- Phase I (FY 2000 - FY 2006)
    - Install STVSs at eight FSSs in Alaska.
    - Replace Litton ICSSs at 30 AFSSs. Extend depot maintenance contract with Litton beyond June 2002 as necessary until all Litton ICSSs are replaced
    - Install four VSRSs at Aeronautical Center and Technical Center
    - Air/ground call transfer can begin on a trial basis
- Phase II (FY 2007 - FY 2009)
    - Replace Litton ICSS at one AFSS and Denro ICSSs at 30 AFSSs
    - Air/ground call transfer can be implemented fully

The recommended performing organization for program execution is the Voice Switching and Recording product team, AND-320.

The schedule of installations is shown in Table 5-I.

TABLE 5-I. SCHEDULE FOR ENHANCEMENT OF FLIGHT SERVICE VOICE
SWITCHING CAPABILITY

	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09
AFSS VSRS				5	7	11	11	11	11	9
Alaska STVS		8								

Annex I, *Acquisition Program Baseline for Flight Service Station Voice Switching Capability*, presents the funding, schedule, benefits, and performance baselines recommended for JRC approval. The recommended F&E funding profile aligns with the current budget, as discussed below.

5.2   Affordability

5.2.1   Capital Investment

F&E funding reserved in the Capital Investment Plan (CIP) to undertake an acquisition program for FSS voice switching capability is identified in line C25.00-00, AFSS Voice Switch Replacement and shown in Table 5-II.

TABLE 5-II. Redacted

Affordability for FSS voice switching capability was determined by the SEOAT on 9 May 2000. The determination stated that an affordable program would be one with a cumulative F&E cost that does not exceed the total F&E budget through FY 2002, and that outyear funding in the CIP will be adjusted to match the acquisition program's F&E cost profile. Thus, the program that is recommended for implementation is affordable.

5.2.2   Funding of Operations

Table 5-III gives the yearly operations costs for service-life extension of the ICSSs and for VSRS replacement switches at all AFSSs, which is shown in summary form in Table 4-II. The operations costs for the VSRSs are exclusive of the costs for telecommunications service to support air/ground call transfer (those costs are shown in Table 4-III).

TABLE 5-III. Redacted

For the initial years of solution implementation, there is a marginal increase in support costs for the recommended solution compared to ICSS service-life extension, because of startup costs for a VSRS acquisition program while continuing to sustain the ICSSs. Costs and benefits associated with air/ground call transfer will be minimal to nonexistent during these years.

Beginning in the latter part of solution implementation, VSRS support costs fall below those projected for ICSS service-life extension. The total avoidance in operations costs over the lifecycle more than $30M. The cost of air/ground call transfer will be offset completely by the benefit of staffing reductions enabled by AFSS part-time operations, as described in 4.5.1 and

4.5.2.

5.2.3   Consideration of Leasing

In lieu of straight purchase of voice switches for flight service stations (both AFSSs and the Alaska FSSs), various forms of leasing were considered (straight lease, lease with option to purchase, and lease to ownership). Lease to ownership essentially is a form of financing. Lease with option to purchase, other things being equal, usually will cost more than straight lease. For the federal government, in addition to cash flow, "color of money" is an issue in a "lease-vs.-buy" decision.

Apart from these issues, leasing is best for a short-term need such that the product still has significant residual value at the conclusion of the need, or for a need that is to be satisfied with a rapid-obsolescence COTS product that must be refreshed during the course of the need. In the latter case, a performance-based contract that provides the vendor incentive to refresh the technology used to satisfy the need is a better approach than leasing hardware and software. Neither of these conditions pertains strongly to enhancement of flight service voice switching capability.

In particular, for AFSS replacement voice switches, the FAA would be required to reimburse the vendor for the front-end, nonrecurring engineering costs to modify its existing product to satisfy Air Traffic requirements regardless of the acquisition method. In a lease situation, the vendor most likely would be reluctant to absorb these costs before placing product in revenue service. For the FAA, the outcome of a lease-vs.-buy analysis would depend on vendor terms for amortization or reimbursement of nonrecurring costs, which would be subject to negotiation. In the absence of specific information, the investment analysis team has predicated its recommendation on straight purchase.

5.3   Risk/Uncertainty

Risks and uncertainties associated with undertaking a program for replacement of the current AFSS voice switches and implementation of air/ground call transfer to enable AFSS part-time operations were identified and quantified by consensus of investment analysis team members with experience and expertise in system acquisition and flight service operations. Table 5-IV shows the risk areas and potential risk events identified. It also indicates the assessed likelihood of occurrence for each event and the level of risk, should the event materialize, to the prospects for overall program success, considering any risk management or fallback strategies available.

TABLE 5-IV. IDENTIFIED RISKS FOR RECOMMENDED SOLUTION

Risk (failure to realize identified capability)	Likelihood of Occurrence	Risk Level	Management/Fallback Strategy (for "high" and "medium" risk levels)
Technical/operational feasibility			
Basic switching system[1]	Low	Low	
Call transfer capability[2]	Medium	Medium	Require convincing descriptions or demonstrations from bidders before contract award/continue program as pure infrastructure modernization
Installation and cutover[3]	Medium	Low/ Medium	Conduct thorough site surveys and schedule around "difficult" sites until solutions (technical or

			operational) can be devised and coordinated
Benefits realization			
Support cost avoidance	Low	Medium	Negotiate favorable terms for contract depot maintenance support and vendor incentives for technology refreshment
Increased utilization efficiency of staff resources	Medium	Medium	Conduct early trials of AFSS part-time operations to demonstrate staff-reduction benefits/continue program as pure infrastructure modernization
Preservation of current level of service accessibility	Medium	Low	(Most likely to occur during equipment/procedures transition)
Baseline adherence			
Cost[4]	Medium	Medium	Resist changes to requirements/abandon selected requirements and/or reduce number of installations
Schedule	High	Medium	Coordinate switch installation schedule with Air Traffic's part-time operations plan and resist changes
Executability			
Availability of required funding	High	High	Adhere to cost and schedule baselines and conduct early trials of AFSS part-time operations to demonstrate benefits/implement clusters delivering greatest benefits if installations are reduced
Acceptance and transition[5]	Medium	Low	(Assure thorough and ongoing coordination with work force regarding introduction of new equipment and operational procedures)
Availability of supporting ground telecommunications	Low	Medium	Assure availability of OPS funding for telecommunications/deactivate RCO sites to remain budget-neutral

Notes:
1. Includes human factors considerations.
2. Includes INFOSEC considerations.
3. On a site-by-site basis.
4. Assuming availability of required funding.
5. On a national airspace system-wide basis.

The greatest risks to program success are failure to satisfy stated requirements (specifically, call transfer capability) during product modification and demonstration, failure to realize sufficient cost avoidance in implementing AFSS part-time operations, and the always-present specter of reduction in capital funding during program execution. However, the overall risk to success of the program as defined herein is considered low.

6.   SUMMARY OF RECOMMENDED DECISIONS

- *Approve the technical solution and program strategy*

  - Install Voice Switch Replacement Systems (VSRSs) with call transfer capability, based on commercial technology and acquired through full and open competition, at 61 AFSSs

  - Install the Small Tower Voice Switches (STVSs), acquired through the current Litton STVS contract, at eight Alaska non-automated FSSs

- *Approve the program schedule shown in Annex II*

  - Install the VSRSs in two phases, replacing the Type III Integrated Communications Switching Systems (ICSSs) manufactured by Litton during Phase I

  - Install the STVSs during FY 2001

  - Replace Type III ICSSs manufactured by Denro in Phase II

- *Redacted*

- *Assign responsibility for program execution to the Voice Switching and Recording product team (AND-320) of the Communications integrated product team.*

APPENDIXES

A. REFERENCES

1. Federal Aviation Administration, Air Traffic Services, Mission Need Statement 320, *Voice Switching Capability for Flight Service Stations*, 5 August 1997.

2. Federal Aviation Administration, Joint Resources Council, *Record of Decision for Mission Need Statement 320, Voice Switching Capability for Flight Service Stations*, 5 August 1997. The mission need statement was approved without revision.

3. Federal Aviation Administration, Air Traffic Operations Service, *Flight Service Architecture Core Group Report*, 30 April 1998. This staff study discusses operational concepts that would reduce the number of automated flight service stations providing in-flight (air/ground) and preflight (ground/ground) services on a 24-hour basis. The study recommends that some stations operate part-time so as to increase utilization efficiency of flight service staff resources during periods of low demand, leading to the need for air/ground call transfer capability at automated flight service stations.

4. Federal Aviation Administration, *National Airspace System Architecture Version 4.0*, January 1999. Presents an evolutionary plan for modernizing the NAS and moving towards free flight. The plan incorporates new technologies, procedures, and concepts intended to meet the needs of NAS users and service providers.

5. (FOUO) Federal Aviation Administration, Office of System Architecture and Investment Analysis, *National Airspace System Initial Information System Security Architecture*, September 1999, draft version. Provides a top-level design for integrating INFOSEC into the NAS. The document advocates a risk-driven approach to remediation and contains little specific information regarding flight services, which are not directed primarily at assuring separation.

6. Federal Aviation Administration, Office of Information Services, Order 1370.82, *Information Systems Security Program* (pending signature of the administrator). Establishes high-level policy and assigns organizational and management responsibilities to ensure FAA implementation of regulations and directives for executive departments and agencies pertaining to security of information systems and resources.

7. Skitka, L. et al., "Does Automation Bias Decision-making?", *International Journal of Human-Computer Studies*, November 1999. Compares the responses of test groups to various simulated in-flight situations based on indications of traditional flight instruments only and of traditional flight instruments in combination with an automated decision aid. The study concluded that various sociological phenomena can result in excessive reliance by flight crews on computer indications because of failure to cross-check these indications with other sources of information.

B.   TECHNICAL CONSIDERATIONS FOR AIR/GROUND CALL TRANSFER AND SUPPORTING TELECOMMUNICATIONS SERVICE

1. Transmission delay through a replacement voice switch may be as low as three milliseconds (ms). However, some vendors have stated delays as high as 50-100 ms through their systems, which in some cases are proprietary virtual networks. FAA Bandwidth Manager equipment also adds delay of about three ms at each node. The limit for overall communications delay (response time) of 250 ms *prior to initiation of voice communications* is imposed by NAS-SR-1000, paragraph 3.6.1.A.

   Voice packets particularly are sensitive to delay. Contributors include:

   - *Accumulation delay*. This is dependent on the codec (e.g., G.721) or vocoder (e.g., G.728) implemented. For example, G.728 at 16 kilobits/second may incur 2.5 ms delay
   - *Processing delay*. This is a function of the packetization processing of the voice samples from the codec or vocoder
   - *Network delay*. This is the propagation delay across the network.

   Consider evaluation of the statistics-gathering capabilities of the telecommunications architecture to track quality of service (QoS) (e.g., lost packets, delay, jitter) to help solve performance problems. Consider diagnostic software for operational network debugging.

2. Priority calls should be identified so that calls on emergency frequencies will not be blocked.

   QoS prioritization particularly is important for voice applications, in that speech fragmentation can occur if voice packets aren't given priority. ATM has inherent QoS capabilities, but IP would require special protocols (e.g. RSVP, MPLS) for prioritization and bandwidth allocation.

3. Consider protocol issues related to any difference between air/ground push-to-talk voice and ground/ground interphone voice that would impact their being handled over the same circuit. Also, some codecs don't process dual-tone multifrequency (DTMF) tones, so separate tone detection must be deployed in parallel if DTMF tones are used for signaling.

4. Voice compression would offer reduction in bandwidth requirements but may have voice quality impact. Voice compression is not assumed for any telecommunications alternative considered.

5. Consider echo cancellation and jitter buffering with adaptive-packet playout (to mitigate variations in packet arrival times). Evaluate features for lost packet compensation. For efficiency, deploy Voice Activity Detection and adaptive Comfort Noise Generation to minimize bandwidth consumption during breaks in conversation while at the same time providing background noise so that a user knows a line is still available.

C.   ACTIVITY-FIVE COST ESTIMATE

Table C-I shows the estimated lifecycle personnel costs for Federal employees who will work on the acquisition of FSS replacement voice switches. These employee costs will be funded by Activity 5 of the agency's F&E budget, not the budget line item for the acquisition program. They thus represent a cost to the agency for FSS replacement voice switches but not a direct cost to the acquisition program.

TABLE C-I. F&E LIFECYCLE COST FOR FEDERAL EMPLOYEES WORKING ON FSS REPLACEMENT VOICE SWITCH ACQUISITION

COST ELEMENT	Solution Implementation										In-service Management										ELEMENT TOTAL
	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19	
Program Management	0.3	0.4	0.5	0.5	0.4	0.3	0.3	0.3	0.4	0.4	0.4										4.2
Proposal Evaluation and OCT																					
NRE and Test Activities (less INFOSEC and NIMS			0.2	0.2																	0.4
INFOSEC																					
NIMS																					
OASIS Console Redesign/Modification																					
Infrastructure Upgrade/Site Preparation																					
Acquisition and Installation																					
Documentation and Training			0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.9
Supporting Ground Telecommunications																					
VSRS Sustainment (ramping up)					0.1	0.2	0.4	0.4	0.4	0.4	0.3	0.1									2.3
ICSS Sustainment (ramping down)																					
Alaska FSS STVSs																					
TOTAL	0.3	0.4	0.8	0.9	0.6	0.7	0.9	1.0	1.0	0.9	0.7	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	9.1

Note: Totals may not reflect sums of entries because of rounding